| FORM PTO-1390<br>(REV 11-2000) | U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE | ATTORNEY'S DOCKET NUMBER<br>1275-45 |
|---|---|---|
| **TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371** | | U S APPLICATION NO. (If known, see 37 C.F.R. 1.5)<br>09/914009<br>Unknown |
| INTERNATIONAL APPLICATION NO.<br>PCT/JP00/01162 | INTERNATIONAL FILING DATE<br>29 February 2000 | PRIORITY DATE CLAIMED<br>1 March 1999 |

TITLE OF INVENTION

**SPREAD-SPECTRUM COMMUNICATION DEVICE**

APPLICANT(S) FOR DO/EO/US

**FUKUMASA**

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.

2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.

3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.

4. ☒ The U.S. has been elected by the expiration of 19 months from the priority date (Article 31).

5. A copy of the International Application as filed (35 U.S.C. 371(c)(2)).
   - a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   - b. ☒ has been communicated by the International Bureau.
   - c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).

6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
   - a. ☒ is attached hereto.
   - b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).

7. ☐ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   - a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   - b. ☐ have been communicated by the International Bureau.
   - c. ☐ have not been made; however, the time limit for making such amendments has **NOT** expired.
   - d. ☐ have not been made and will not be made.

8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).

9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).

10. ☒ A English language translation of the annexes of the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

**Items 11 To 20 below concern document(s) or information included:**

11. ☐ An Information Disclosure Statement under 37 C.F.R. 1.97 and 1.98.

12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 C.F.R. 3.28 and 3.31 is included.

13. ☒ A FIRST preliminary amendment.

14. ☐ A SECOND or SUBSEQUENT preliminary amendment.

15. ☐ A substitute specification.

16. ☐ A change of power of attorney and/or address letter.

17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821-1.825.

18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).

19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).

20. ☒ Other items or information. PTO-1449/ International Search Report/ Front page of the PCT Publication

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| U.S. APPLICATION NO. (If known, see 37 CFR 1.5) | INTERNATIONAL APPLICATION NO PCT/JP00/01162 | ATTORNEY'S DOCKET NUMBER 1275-45 |
|---|---|---|

**09/981 009 Unknown**

21. ☒ The following fees are submitted:

| | | CALCULATIONS | PTO USE ONLY |
|---|---|---|---|

**BASIC NATIONAL FEE (37 C.F.R. 1.492(a)(1)-(5)):**

-- Neither international preliminary examination fee (37 C.F.R. 1.482) nor international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .......................$1000.00

-- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO...................$860.00

-- International preliminary examination fee (37 C.F.R. 1.482) not paid to USPTO but international search fee (37 C.F.R. 1.445(a)(2)) paid to USPTO .......................$710.00

-- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4)...............$690.00

-- International preliminary examination fee (37 C.F.R. 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4).......................................$100.00

| | | | |
|---|---|---|---|
| ENTER APPROPRIATE BASIC FEE AMOUNT = | | $ 860.00 | |

Surcharge of $130.00 for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(e)).

| | | | | | | $ 0.00 | |
|---|---|---|---|---|---|---|---|

| CLAIMS | NUMBER FILED | | NUMBER EXTRA | RATE | | | |
|---|---|---|---|---|---|---|---|
| Total Claims | 8 | -20= | 0 | X | $18.00 | $ 0.00 | |
| Independent Claims | 2 | -3 = | 0 | X | $80.00 | 0.00 | |
| MULTIPLE DEPENDENT CLAIMS(S) (if applicable) | | | | | $270.00 | $ 0.00 | |
| | | | TOTAL OF ABOVE CALCULATIONS = | | | $ 860.00 | |

☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by 1/2.

| | | | 0.00 | |
|---|---|---|---|---|
| | | SUBTOTAL = | $ 860.00 | |

Processing fee of $130.00, for furnishing the English Translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 C.F.R. 1.492(f)). +

| | | | 0.00 | |
|---|---|---|---|---|
| | TOTAL NATIONAL FEE = | | $ 860.00 | |

Fee for recording the enclosed assignment (37 C.F.R. 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 C.F.R. 3.28, 3.31). **$40.00** per property +

| | | | $ 40.00 | |
|---|---|---|---|---|
| Fee for Petition to Revive Unintentionally Abandoned Application ($1240.00 – Small Entity = $620.00) | | | $ 0.00 | |
| | | TOTAL FEES ENCLOSED = | $ 900.00 | |
| | | | Amount to be: refunded | $ |
| | | | Charged | $ |

a. ☒ A check in the amount of $900.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. 14-1140 in the amount of $_____ to cover the above fees. A duplicate copy of this form is enclosed.

c. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 14-1140. A <u>duplicate</u> copy of this form is enclosed.

d. ☒ The entire content of the foreign application(s), referred to in this application is/are hereby incorporated by reference in this application.

**NOTE: Where an appropriate time limit under 37 C.F.R. 1.494 or 1.495 has not been met, a petition to revive (37 C.F.R. 1.137(a) or (b)) must be filed and granted to restore the application to pending status.**

**SEND ALL CORRESPONDENCE TO:**

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SIGNATURE

**Michael J. Shea**
NAME

**34,725**
REGISTRATION NUMBER

**August 22, 2001**
Date

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553094

## IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of

FUKUMASA

Serial No. Unknown

Filed: August 22, 2001

For:   SPREAD-SPECTRUM COMMUNICATION DEVICE

Atty. Ref.:  1275-45

Group:

Examiner:

\*   \*   \*   \*   \*   \*   \*   \*   \*   \*   \*

August 22, 2001

Assistant Commissioner for Patents
Washington, DC  20231

Sir:

### PRELIMINARY AMENDMENT

In order to place the above-identified application in better condition for examination, please amend the application as follows:

### IN THE CLAIMS

Please substitute the following amended claims for corresponding claims previously presented.  A copy of the amended claims showing current revisions is attached.

4. (Amended) The spectrum spread communication system according to Claim 1, further comprising:

a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

7. (Amended) The spectrum spread communication system according to Claim 5, further comprising:
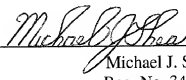
a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

## REMARKS

The above amendments are made to place the claims in a more traditional format. Attached hereto is a marked-up version of the changes made to the claims by the current amendment. The attached page is captioned "**Version With Markings To Show Changes Made**."

Respectfully submitted,

**NIXON & VANDERHYE P.C.**

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## VERSION WITH MARKINGS TO SHOW CHANGES MADE

## IN THE CLAIMS

4. (Amended) The spectrum spread communication system according to Claim 1 ~~or 2~~, further comprising:

a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

7. (Amended) The spectrum spread communication system according to Claim 5 ~~or 6~~, further comprising:

a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

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DESCRIPTION


SPREAD SPECTRUM COMMUNICATION SYSTEM


5    Technical Field

         The present invention relates to a spread spectrum

    communication system based on the direct sequence spreading

    scheme, for a portable phone and mobile communication system,

    for example.

10

    Background Art

         In recent years, research and development as to mobile

    communication systems using the spread spectrum technology

    based on the direct sequence spreading scheme have been

15   extensively made.  Such communication systems include a

    system used worldwide and known as cdmaOne, and the W-CDMA

    system and the Wideband cdmaOne(cdma2000) system which both

    are aiming at the standard for IMT-2000 (see Tero Ojanperä

    and Ramjee Prasad, "An Overview of Air Interface Multiple

20   Access for IMT-2000/UMTS", IEEE Communications Magazine,

    September 1998. etc.).  Among these, particularly for the

    W-CDMA, use of roll-off filters having small roll-off ratios

    is demanded in order to reduce the required bandwidth as small

    as possible relative to the chip rate.  As the spread spectrum

25   communication system for this scheme, a method combined with

QPSK(quadri-phase shift keying) has been proposed.

Fig.1 shows a block diagram of a transmitter of this spread spectrum communication system of the QPSK scheme. The transmitter of this spread spectrum communication system is comprised of a complex spreading portion 701 for performing complex spreading modulation of data $D_i$ and $D_q$ which are the I-phase component(in-phase component) and the Q-phase component(quadrature-phase component) of the transmission signal, roll-off filters 708 and 709, a carrier modulator 716, a power amplifier 715 and an antenna 717.

Complex spreading portion 701 includes multipliers 702 to 705 for multiplying the I-phase and Q-phase data by complex number sequences $W_0$ and $W_1$ and adders 706 and 707 each performing addition of the I-phase and Q-phase data modulated by $W_0$ and $W_1$.

Carrier modulator 716 includes a sinusoidal wave generating circuit 710, a phase-rotation circuit 713 for rotating the phase of the sinusoidal wave by $\pi/2$, a multiplier 711 for modulating the data having passed through roll-off filter 708 by the sinusoidal wave and a multiplier 712 for modulating the data having passed through roll-off filter 709 by the sinusoidal wave rotated in phase by $\pi/2$, and an adder 714 for performing addition of these pieces of modulated data.

However, since the signal waveforms having passed through

the roll-off filters present large dynamic ranges, a spread
spectrum communication system of this type may be demanded
high linearity for a power amplifier and other circuits.

To deal with the problem of this kind, Japanese Patent
5      Publication Hei 7 No.312391 discloses a spread spectrum
transmitter/receiver in which spectrum spreading and a $\pi$
/4 shift QPSK are applied in combination. In this $\pi$/4 shift
QPSK, since the positions of the signal points of sequential
symbols differ in phase by $\pi$/4 from each other, the envelop
10     will not cut the point '0' when the signal transits from one
signal point to another, so that the variations of the envelop
is known to be small. This effect can be similarly obtained
when it is applied to a spread spectrum scheme.

On the other hand, as found in 'Global CDMA $\mathrm{II}$ for IMT-2000
15     RTT System Description' TTA, Korea (June 17, 1998), a special
spreading scheme based on the combination of pseudo-random
sequence and Walsh sequence has been also proposed. Now, this
scheme is called OCQPSK(orthogonal complex QPSK) and the block
diagram is shown in Fig.2.

20     The transmitter for the spread spectrum communication
system based on this OCQPSK scheme is comprised of multipliers
802 and 803 for modulating the I-phase and Q-phase data $D_i$
and $D_q$ by Walsh sequences $W_0$ and $W_2$, respectively, a complex
spreading portion 801 for performing complex spreading
25     modulation, multipliers 810 and 811 for scrambling the data

with pseudo-random sequences PN$^{(k)}$, roll-off filters 812 and
813, a carrier modulator 820, a power amplifier 819 and an
antenna 821.

Complex spreading portion 801 includes multipliers 804
to 807 for multiplying the I-phase and Q-phase data modulated
by $W_0$ and $W_2$ by complex number sequences $W_0$ and $W_1$, and adders
808 and 809 each performing addition of the I-phase and Q-phase
data modulated by $W_0$ and $W_1$.

Carrier modulator 820 includes a sinusoidal wave
generating circuit 814, a phase-rotation circuit 817 for
rotating the phase of the sinusoidal wave by $\pi/2$, a multiplier
815 for modulating the data having passed through roll-off
filter 812 by the sinusoidal wave and a multiplier 816 for
modulating the data having passed through roll-off filter
813 by the sinusoidal wave rotated in phase by $\pi/2$, and an
adder 818 for performing addition of these pieces of modulated
data.

In this spread spectrum communication system, the I-phase
data $D_i$ and Q-phase data $D_q$ are modulated by Walsh sequences
$W_0$ and $W_2$ and further processed through complex spreading
portion 801 where the signals are subjected to complex
spreading modulation using complex number sequences made up
of $W_0$ and $W_1$. Further, the output signals are scrambled by
a pseudo-random sequence PN$^{(k)}$ uniquely allotted to the user.
The signals are then passed through the roll-off filters and

are processed through carrier modulating portion 820, where the signals are carrier-modulated to be output to power amplifier 819. This method has the feature of limiting the phase transition of the signal to reduce the amplitude variation of the signal by performing spread modulation using complex number sequences made up of Walsh sequences.

The method disclosed by Japanese Patent Publication Hei 7 No.312391 is able to improve the characteristic compared to the QPSK spreading modulation, however, the degree of the improvement is not so large and hence is not large enough to meet the conditions required by W-CDMA.

The OCQPSK scheme is able to provide a certain degree of improvement, however, this is not good enough. That is, the reason why the OCQPSK cannot produce high enough improvement is that the Q-phase data $D_q$ is spread modulated by codes represented by $W_2$ or that the signal is varied in phase by units of 90 degrees every two chips when the signal is input to complex spreading portion 801 shown in Fig.2. Since the restriction on phase transition is effective only when the phase of the symbol does not vary, the effect of restriction on phase transition is limited to one of two transitions, thus sharp improvement of the characteristics cannot be obtained.

It is therefore an object of the present invention to provide a spread spectrum communication system in which the

requirement on the linearity for the amplifier etc. can be alleviated by inhibiting the amplitude variations of the signal more tightly than the above schemes, thus allowing for use of a compact, low-cost and energy saving transmitter.

5

Disclosure of Invention

In order to solve the above problem, the present invention is configured as follows:

The first aspect of the invention is a spread spectrum

10 communication system including a transmitter and receiver for performing spread spectrum communications based on a direct sequence spreading scheme and is characterized in that the transmitter includes: a complex spread portion for multiplying an I-phase component signal and a Q-phase

15 component signal of the transmission signal by one type of complex number sequence which will not cause any phase transition of a signal on the I-Q plane in the direction toward the origin; a multiplier for multiplying the signals output from the complex spreading portion by a pseudo-random sequence

20 which is generated at a speed exceeding the symbol rate; a roll-off filter for waveform shaping; and a carrier modulator for performing carrier modulation of the signals having undergone waveform shaping, and that the receiver includes: a carrier demodulator for performing carrier demodulation

25 of the received signal; a multiplier for multiplying the two

types of signals output from the carrier demodulator by the pseudo-random sequence generated at the same speed as above; a complex despreading portion for performing despreading by multiplying each signal by the complex number sequence; and

5      a phase-correcting portion for performing phase-correction so as to extract the I-phase and Q-phase components.

The second aspect of the invention is the spectrum spread communication system defined in the first aspect and is characterized in that the complex spreading portion includes:

10     a multiplier for multiplying the I-phase component signal and Q-phase component signal of the transmission signal by the complex number sequence; and an adder for performing addition of the I-phase component signal and Q-phase component signal of the transmission signal respectively to the Q-phase

15     component signal and I-phase component signal multiplied by the complex number sequence, and that the complex despreading portion wherein the complex despreading portion performs the despreading includes: a  multiplier for multiplying the signals by the complex number sequence; and an adder for

20     performing addition of the signals to the signals multiplied by the complex number sequence, respectively.

The third aspect of the invention is the spectrum spread communication system defined in the first or second aspect, and is characterized in that the complex number sequence is

25     a pattern in which the I-phase component is constantly set

at 1 or -1 and the Q-phase component changes between 1 and -1 alternately.

The fourth aspect of the invention is the spectrum spread communication system defined in any of the first through third aspects, and further includes: a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

The fifth aspect of the invention is a spread spectrum communication system including a transmitter and receiver for performing spread spectrum communications based on a direct sequence spreading scheme, and is characterized in that the transmitter includes: a permuting processor for permuting the I-phase component signal and the Q-phase component signal of the transmission signal, once every two clock units and at the same time inverting the sign of one of the component signals; a multiplier for multiplying the signals output from the complex spreading portion by a pseudo-random sequence which is generated at a speed exceeding the symbol rate; a roll-off filter for waveform shaping; and a carrier modulator for performing carrier modulation of the signals having undergone waveform shaping, and that the receiver includes: a carrier demodulator for performing carrier demodulation of the received signal; a multiplier for multiplying the two types of signals output from the carrier demodulator by the pseudo-random sequence generated at the

same speed as above; a permuting processor for permuting the signal multiplied by the pseudo-random sequence, once every two clock units and at the same time inverting the sign of the component signal which underwent sign inversion at the transmitter; and a phase-correcting portion for performing phase-correction so as to extract the I-phase and Q-phase components.

The sixth aspect of the invention is the spectrum spread communication system defined in the fifth aspect, and is characterized in that the permuting processor includes: a multiplier for multiplying one of the component signals of the transmission signal by -1; and a switch which, based on a control signal of 1 and 0 appearing alternately, switches between the combination of the I-phase component signal and Q-phase component signal of the transmission signal and the combination of one component signal multiplied by -1 and the other component signal, and that the permuting inverse processor includes: a multiplier for multiplying the signal which was multiplied by the pseudo-random sequence by -1; a switch which, based on a control signal of 1 and 0 appearing alternately, switches between the combination of the signals which were multiplied by a pseudo-random sequence and the combination between the signal multiplied by -1 and the other signal multiplied by another pseudo-random sequence.

The seventh aspect of the invention is that the spectrum

spread communication system defined in the fifth or sixth aspect, and further includes: a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

The eighth aspect of the invention is the spectrum spread communication system defined in the seventh aspect, and is characterized in that the mapping circuit maps each of the signals to the I-phase and Q-phase and independently sets the I-phase or Q-phase amplitude and symbol rate, if required.

The ninth aspect of the invention, the spectrum spread communication system defined in the seventh aspect, and is characterized in that the mapping circuit has the mapping function of mapping, when a multiple number of data channels are needed to be allotted in response to an information transfer request arising regularly or eventually, the data onto the I-Q plane by using a multiple number of orthogonal sequences whereby increase in symbol rate due to mapping is minimized.

Brief Description of the Drawings

Fig.1 is a block diagram showing a transmitter in a conventional QPSK spread spectrum communication system;

Fig.2 is a block diagram showing a transmitter in a conventional OCQPSK spread spectrum communication system;

Fig.3 is a block diagram showing the first embodiment of a spread spectrum communication system in accordance with

the present invention, (a) and (b) being a transmitter and receiver, respectively;

Fig.4 shows characteristic charts representing time-dependent variations in amplitude of the signals having passed through roll-off filters, (a) for a typical QPSK system, (b) for OCQPSK system and (c) for a system of the first embodiment;

Fig.5 shows characteristic charts representing the cumulative probability distribution of the instantaneous value of the roll-off filter output value, (a) representing the peak value distributions in the above systems and (b) representing the minimum value distributions;

Fig.6 is a block diagram showing the second embodiment of a spread spectrum communication system in accordance with the present invention;

Fig.7 shows illustrative diagrams representing the allocations of the signal points according to the first and second embodiments; and

Fig.8 is a block diagram showing the third embodiment of a spread spectrum communication system in accordance with the present invention.

Best Mode for Carrying Out the Invention

Next, the embodiments of the present invention will be described with reference to the drawings.

<The First Embodiment>

Fig.3 is a block diagram showing the first embodiment of a spread spectrum communication system in accordance with the present invention, Fig.3(a) and Fig.3(b) showing a

5    transmitter and receiver, respectively.

As shown in Fig.3(a), the transmitter is comprised of a complex spreading portion 301 for performing complex spreading modulation of the I-phase and Q-phase data $D_i$ and $D_q$ of a transmission signal, multipliers 306 and 307 for

10   scrambling the data with a pseudo-random sequence $PN^{(k)}$ which is generated at a speed equal to or above some times or some hundreds times of the symbol rate, roll-off filters 308 and 309 for waveform shaping, a carrier modulator 316, a power amplifier 315 and an antenna 317.

15   Complex spreading portion 301 includes a multiplier 305 for multiplying the I-phase data $D_i$ by a complex number sequence of 1 and -1 appearing alternately, a multiplier 304 for multiplying the Q-phase data $D_q$ by the above complex number sequence, an adder 302 for adding the modulated data through

20   multiplier 304 to the I-phase data $D_i$ and an adder 303 for adding the modulated data through multiplier 305 to the Q-phase data $D_q$.

The data output from adder 302 is supplied to multiplier 306 and the data from adder 303 is supplied to multiplier

25   307.

Carrier modulator 316 includes a sinusoidal wave generating circuit 312, a phase-rotation circuit 313 for rotating the sinusoidal wave in phase by $\pi/2$ at the same speed as that at which pseudo-random sequence $PN^{(k)}$ is generated,

5 a multiplier 310 for modulating the data having passed through roll-off filter 308 by the sinusoidal wave and a multiplier 311 for modulating the data having passed through roll-off filter 309 by the sinusoidal wave rotated in phase by $\pi/2$, and an adder 314 for performing addition of these modulated

10 data.

First, the transmission signal is separated into the I-phase component and the Q-phase component, which are input to complex spreading portion 301. In complex spreading portion 301, the data is spread by a complex number sequence

15 pattern of 1 and -1 appearing alternately through multipliers 304 and 305 and adders 302 and 303. Therefore, if no change occurs in data, the signal outputs from complex spreading portion 301 continuously change in phase by ±90 degrees.

The output from complex spreading portion 301 is

20 modulated by pseudo-random sequences $PN^{(k)}$ (x) allotted to each user through multipliers 306 and 307. Then, the signal is wave-shaped through roll-off filters 308 and 309 so that the baseband signal is modulated by carrier modulator 316, so that the resulting signal is supplied to power amplifier 315,

25 where it is amplified and transmitted from antenna 317.

As shown in Fig.3(b), the receiver is comprised of an antenna 321, a carrier demodulator 322, multipliers 327 and 328 for demodulating the signal with pseudo-random sequence $PN^{(k)}(x)$, a complex despreading portion 329 for performing complex despreading and a phase rotating circuit 334 for performing phase correction based on the reference phase.

Carrier demodulator 322 includes a sinusoidal wave generating circuit 323, a phase rotating circuit 325 for rotating the sinusoidal wave in phase by $\pi/2$, a multiplier 324 for demodulating the received signal through antenna 321 by the sinusoidal wave and a multiplier 326 for demodulating the received signal through antenna 321 by the sinusoidal wave rotated in phase by $\pi/2$.

Multiplier 324 outputs the demodulated signal to multiplier 327.

Multiplier 326 outputs the demodulated signal to multiplier 328.

Complex despreading portion 329 includes a multiplier 333 for multiplying the output signal from multiplier 327 by the complex number sequence, a multiplier 332 for multiplying the signal output from multiplier 328 by the complex number sequence, an adder 330 for adding the output signal from multiplier 332 to the signal output from multiplier 327, an adder 331 for adding the output signal from multiplier 333 to the signal output from multiplier 328 and

integrate-and-dump filters 332 and 333 for performing waveform
shaping of the signals received from adders 330 and 331.

On the receiver side, the signal after the demodulation
through carrier demodulator 322 is multiplied with x, i.e.,
pseudo-random sequence $PN^{(k)}$, through multipliers 327 and 328.
Then the signal is further despread through complex
despreading portion 329 and is corrected in phase by phase
rotating circuit 334 based on the reference phase information
determined using a pilot symbol etc., whereby I-phase and
Q-phase information is extracted.

In this spread spectrum communication system, the data
is spread using the complex number sequence pattern of 1 and
-1 appearing alternately, instead of performing modulation
by $W_0$ and $W_2$ prior to complex spreading portion 801 shown in
Fig.2, so that the signal output from complex spreading portion
301 will continuously change in phase by ±90 degrees as long
as the data is constant. In this way, the signal input to
complex spreading portion 301 is prevented to change at a
rate greater than the symbol rate, whereby the effect of phase
transition restriction can be enhanced. Thus, phase
transition of the spread signal is restricted so as to reduce
the amplitude variations of the signal, which makes it possible
to alleviate the linearity requirement on the amplifier. An
example of the time-dependent variation in amplitude of the
signal having passed through the root roll-off filter having

a roll-off factor of 0.22 is shown in Fig.4.

The chart shown in Fig.4(a) represents the characteristic of the amplitude variation of a signal which is spread modulated through a typical QPSK spread system and then passed through the root roll-off filter. In contrast, the Fig.4(b) represents the case using the OCQPSK scheme and Fig.4(c) represents the amplitude variation when the first embodiment is applied. The amplitude variation range of the OCQPSK scheme turned out to be smaller than that of the QPSK scheme. The first embodiment presented a further smaller variation range, proving improvement.

Fig.5 shows the cumulative probability distribution of the instantaneous value of the roll-off filter output value. Fig.5(a) represents the peak value distributions of the above systems and Fig.5(b) represents the minimum value distributions. Since the present embodiment shows the lowest peak value and the largest minimum, it is understood that the amplitude variation range is the smallest compared to the other systems.

<The Second Embodiment>

Fig.6 is a block diagram showing the second embodiment of a spread spectrum communication system in accordance with the present invention. This spread spectrum communication system represents its transmitter, which comprised of a multiplier 401 for multiplying the I-phase data $D_i$ by $-1$ and

a switching circuit 402, instead of the complex spreading

portion 301 of the first embodiment. Other components are

the same as in the first embodiment so the same reference

numerals as in the first embodiment are allotted. Switching

5    circuit 402 has switches 403 and 404 controlled in accordance

with a control signal.

The transmission signal is separated into the I-phase

and Q-phase components and input to switching circuit 402.

The I-phase component is processed through multiplier 401

10   so as to continuously generate its negative-phase signal,

which is also supplied to switching circuit 402.

Two switches 403 and 404 in switching circuit 402 are

adapted to operate in accordance with a control signal. When

a signal which alternately changes between 0 and 1 is supplied

15   as the control signal, the inputs are directly output for

even-numbered chips and the inputs $D_i$ and $D_q$ are permuted for

odd-numbered chips. For the latter case, the sign of data

$D_i$ is inverted by multiplier 401 and input. The output from

switching circuit 402 is always shifted in phase by 45 degrees

20   relative that of the first embodiment(see Fig.7). Also in

this case, the signal continuously changes in phase by 90

degrees if no change occurs in data, so that the same effect

as in the first embodiment can be obtained.

The other operation is the same as the first embodiment.

25   Here, no receiver is shown but the switching circuit is

configured so as to perform reverse operations of the
transmitter and the same configuration as in the first
embodiment can be employed for the other parts.

5    <The third embodiment>

Fig.8 is a block diagram showing the third embodiment
of a spread spectrum communication system in accordance with
the present invention, in which a mapping circuit to be disposed
prior to the transmitter shown in Fig.3(a) or Fig.6 is shown.

10   In the first and second embodiments, data is allotted for
I-phase and Q-phase components as transmission data $D_i$ and
$D_q$. However, for multimedia communications to which W-CDMA
is expected to be applied, in order to flexibly deal with
various data rates, multi-rate transmission, multi-code

15   transmission and the like are desired.

Fig.8 shows a mapping circuit 601 for generating the
symbol which is the combination of parallel input data $D^{(0)}$,
$D^{(1)}$, $D^{(2)}$, $\cdots D^{(N-1)}$ and input to the transmitter in Fig.3(a)
or Fig.6.

20   Mapping circuit 601 is configured of multiple multipliers
603 to 604, 606 to 608, $\cdots$, multiple adders 605, 609, $\cdots$,
and circuits for generating orthogonal codes $C_n$. Here, a value
$2^l$ satisfying the condition $2^{l-1} < [N/2] \leqq 2^l$ is determined, where
[x] denotes a minimum integer equal to or greater than x.

25   Under this condition, the symbol rate of the output from

mapping circuit 601 becomes equal to $2^1$ times of the largest symbol rate of the input to mapping circuit 601. For symbol mapping, arbitrary orthogonal codes can be used. As an example, Walsh-Hadamard sequences can be used. Now, a specific example

5      will be shown. $D^{(0)}$ is assumed as a control channel and $D^{(1)}$, $D^{(2)}$ and $D^{(3)}$ are assumed as data channels. The symbol rate of the control channel is 1/256 of the chip rate and the data channel is 1/32.

In this case, it is assumed that $C_0 = 1$, 1 and $C_1 = 1$,

10     -1, so that the outputs from mapping circuit 601 are obtained as follows:

$$D_1 = D^{(0)} \cdot C_0 + D^{(2)} \cdot C_1$$

$$D_q = D^{(1)} \cdot C_0 + D^{(3)} \cdot C_1.$$

For this case, the clock for $C_0$ and $C_1$ becomes equal to twice

15     of that of $D^{(1)}$, $D^{(2)}$ and $D^{(3)}$. Thus, one control channel and three data channels can be mapped to generate a symbol having a speed one-sixteenth of the chip rate. This symbol is input to the circuit shown in Fig.3(a) or Fig.6 and is transmitted. In this way, use of such a mapping circuit makes it possible

20     for a single transmitter to send data involving a multiple pieces of information different in transmission rate and in required quality. The information can be demodulated using one or multiple receivers.

According to the present invention, the signals

25     (information symbols arranged at symbol points) arranged on

the I-Q plane are subjected to spectrum spreading using complex
number sequences devised so as not to cause phase-transition
in a diagonal line direction (toward the origin point), whereby
it is possible to reduce the amplitude variation of the signal
5  after roll-off filters and hence narrow the signal dynamic
range, which allows a relatively low-cost high efficiency
amplifier to satisfy the system specifications as to adjacent
channel interface etc.  As a result, this invention
contributes to reducing the cost of the system and to reducing
10  the power consumption.

Further, use of a mapping circuit makes it possible for
a single transmitter to send data involving a multiple pieces
of information different in transmission rate and in required
quality.

15

Industrial Applicability

As has been described heretofore, the spread spectrum
communication system according to the present invention is
applicable to spread spectrum communication systems of a
20  direct sequence spreading type which is used for portable
phones, mobile communication systems and the like.  Further,
the invention contributes to miniaturization, power saving
and cost reduction of the transmitter.

CLAIMS

1.    A spread spectrum communication system including a
transmitter and receiver for performing spread spectrum
communications based on a direct sequence spreading scheme,
5       the transmitter comprising:
        a complex spread portion for multiplying an I-phase
component signal and a Q-phase component signal of the
transmission signal by one type of complex number sequence
which will not cause any phase transition of a signal on the
10      I-Q plane in the direction toward the origin;
        a multiplier for multiplying the signals output from
the complex spreading portion by a pseudo-random sequence
which is generated at a speed exceeding the symbol rate;
        a roll-off filter for waveform shaping; and
15      a carrier modulator for performing carrier modulation
of the signals having undergone waveform shaping,
the receiver comprising:
        a carrier demodulator for performing carrier
demodulation of the received signal;
20      a multiplier for multiplying the two types of signals
output from the carrier demodulator by the pseudo-random
sequence generated at the same speed as above;
        a complex despreading portion for performing despreading
by multiplying each signal by the complex number sequence;
25      and

a phase-correcting portion for performing phase-correction so as to extract the I-phase and Q-phase components.

5    2.    The spectrum spread communication system according to Claim 1, wherein the complex spreading portion includes:

a multiplier for multiplying the I-phase component signal and Q-phase component signal of the transmission signal by the complex number sequence, and

10    an adder for performing addition of the I-phase component signal and Q-phase component signal of the transmission signal respectively to the Q-phase component signal and I-phase component signal multiplied by the complex number sequence; and

15    the complex despreading portion wherein the complex despreading portion performs the despreading includes:

a multiplier for multiplying the signals by the complex number sequence, and

an adder for performing addition of the signals to the

20    signals multiplied by the complex number sequence, respectively.

3.    The spectrum spread communication system according to Claim 1 or 2, wherein the complex number sequence is a pattern

25    in which the I-phase component is constantly set at 1 or −1

and the Q-phase component changes between 1 and -1 alternately.

4.   The spectrum spread communication system according to any one of Claims 1 through 3, further comprising:

a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

5.   A spread spectrum communication system including a transmitter and receiver for performing spread spectrum communications based on a direct sequence spreading scheme, the transmitter comprising:

a permuting processor for permuting the I-phase component signal and the Q-phase component signal of the transmission signal, once every two clock units and at the same time inverting the sign of one of the component signals;

a multiplier for multiplying the signals output from the complex spreading portion by a pseudo-random sequence which is generated at a speed exceeding the symbol rate;

a roll-off filter for waveform shaping; and

a carrier modulator for performing carrier modulation of the signals having undergone waveform shaping,
the receiver comprising:

a carrier demodulator for performing carrier demodulation of the received signal;

a multiplier for multiplying the two types of signals output from the carrier demodulator by the pseudo-random sequence generated at the same speed as above;

a permuting processor for permuting the I-phase component signal multiplied by the pseudo-random sequence, once every two clock units and at the same time inverting the sign of the component signal which underwent sign inversion at the transmitter; and

a phase-correcting portion for performing phase-correction so as to extract the I-phase and Q-phase components.

6.    The spectrum spread communication system according to Claim 5, wherein the permuting processor includes:

a multiplier for multiplying one of the component signals of the transmission signal by -1; and

a switch which, based on a control signal of 1 and 0 appearing alternately, switches between the combination of the I-phase component signal and Q-phase component signal of the transmission signal and the combination of one component signal multiplied by -1 and the other component signal, the permuting inverse processor includes:

a multiplier for multiplying the signal which was multiplied by the pseudo-random sequence by -1;

a switch which, based on a control signal of 1 and 0

appearing alternately, switches between the combination of the signals which were multiplied by a pseudo-random sequence and the combination between the signal multiplied by -1 and the other signal multiplied by another pseudo-random sequence.

5

7.    The spectrum spread communication system according to Claim 5 or 6, further comprising:

a mapping circuit disposed prior to the transmitter for mapping the multiplexed transmission signals to points on the I-Q plane.

10

8.    The spectrum spread communication system according to Claim 7, wherein the mapping circuit maps each of the signals to the I-phase and Q-phase and independently sets the I-phase or Q-phase amplitude and symbol rate, if required.

15

9.    The spectrum spread communication system according to Claim 7, wherein the mapping circuit has the mapping function of mapping, when a multiple number of data channels are needed to be allotted in response to an information transfer request arising regularly or eventually, the data onto the I-Q plane by using a multiple number of orthogonal sequences whereby increase in symbol rate due to mapping is minimized.
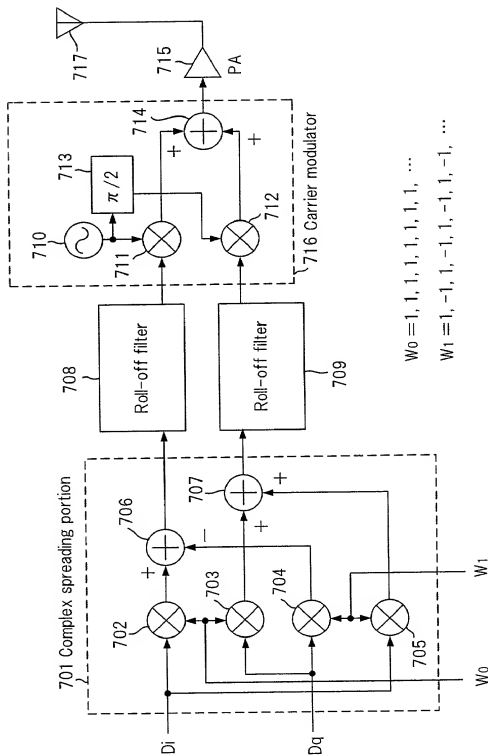
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25

## ABSTRACT

A spread spectrum communication system is to control the signal amplitude variation so as to alleviate the requirement of the linearity on the amplifier etc., thus allowing for use of a compact, low cost and energy saving transmitter.

The transmission signal is separated into the I-phase component and the Q-phase component. In a complex spreading portion(301), spreading is performed by using multipliers (304 and 305) and adders (302 and 303) together with a sequence pattern of 1 and -1 appearing alternately. The outputs from the complex spreading portion (301) are modulated in multipliers(306 and 307) using pseudo-random sequences $PN^{(k)}(x)$ allotted for individual users. The baseband signal which underwent waveform shaping by roll-off filters(308 and 309) is modulated through a carrier modulator(316), then sent to a power amplifier(315), where it is amplified and transmitted via antenna(317).

FIG.1



$W_0 = 1, 1, 1, 1, 1, 1, 1, 1, \ldots$
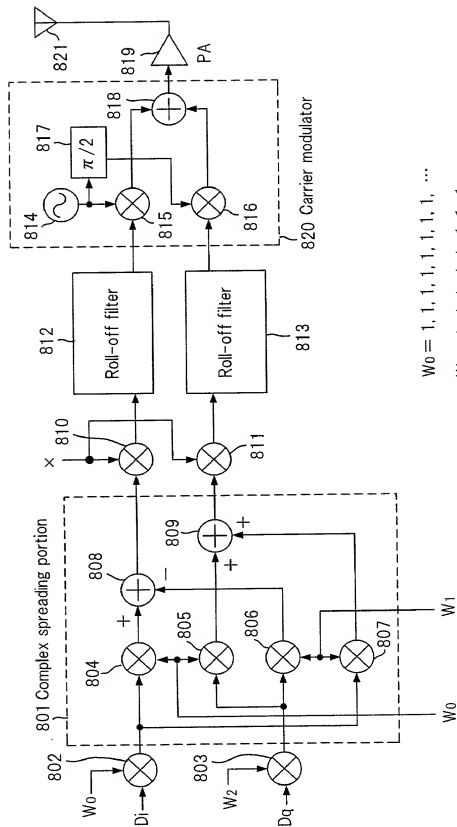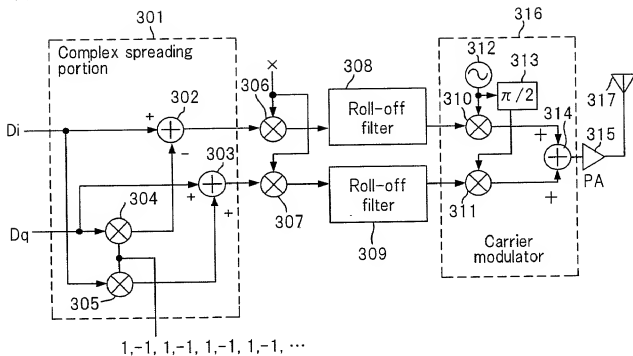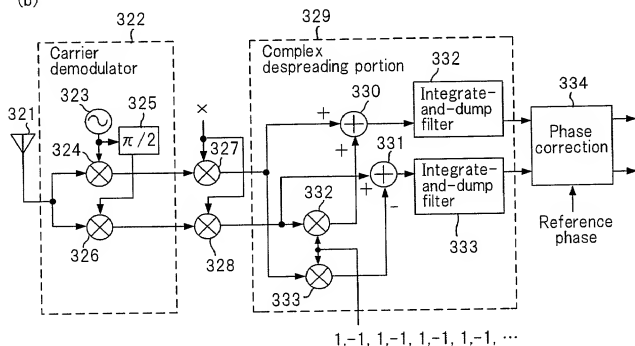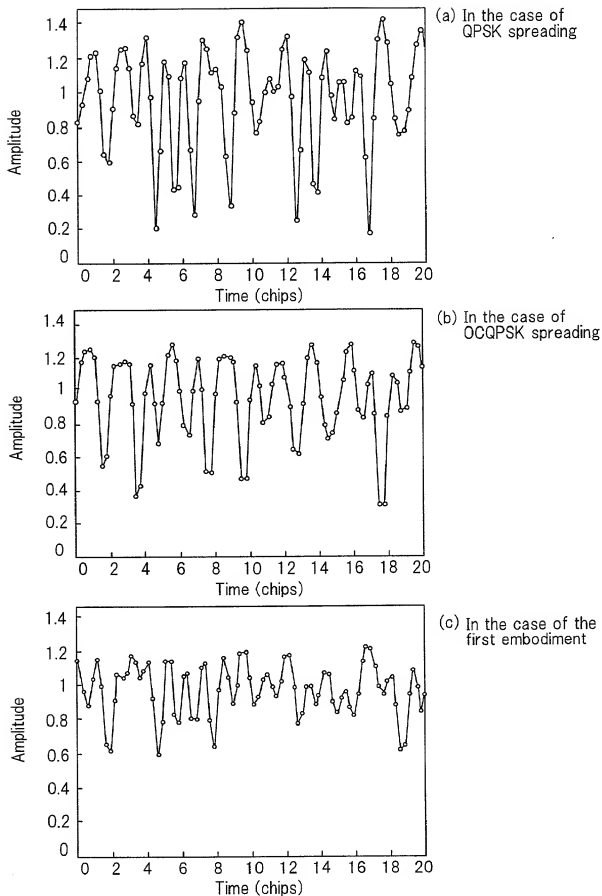$W_1 = 1, -1, 1, -1, -1, 1, -1, 1, -1, \ldots$

FIG. 2

$W_0 = 1, 1, 1, 1, 1, 1, 1, 1, \ldots$
$W_1 = 1, 1, -1, -1, 1, 1, -1, -1, \ldots$
$W_2 = 1, 1, -1, -1, -1, -1, 1, -1, \ldots$

# FIG. 3

(a)



(b)



1,-1, 1,-1, 1,-1, 1,-1, ⋯

# FIG. 4



(a) In the case of QPSK spreading

(b) In the case of OCQPSK spreading

(c) In the case of the first embodiment

# FIG.5

(a)



Peak characteristics

QPSK ——
OCQPSK − − −
New method - - - -

(b)



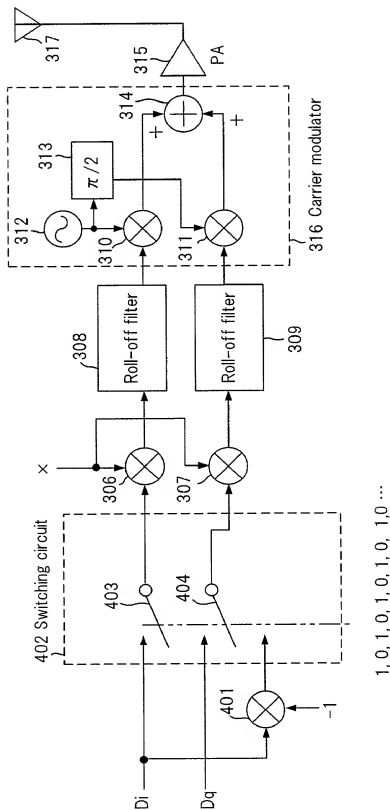Minimum characteristics

QPSK ——
OCQPSK — —
New method -----
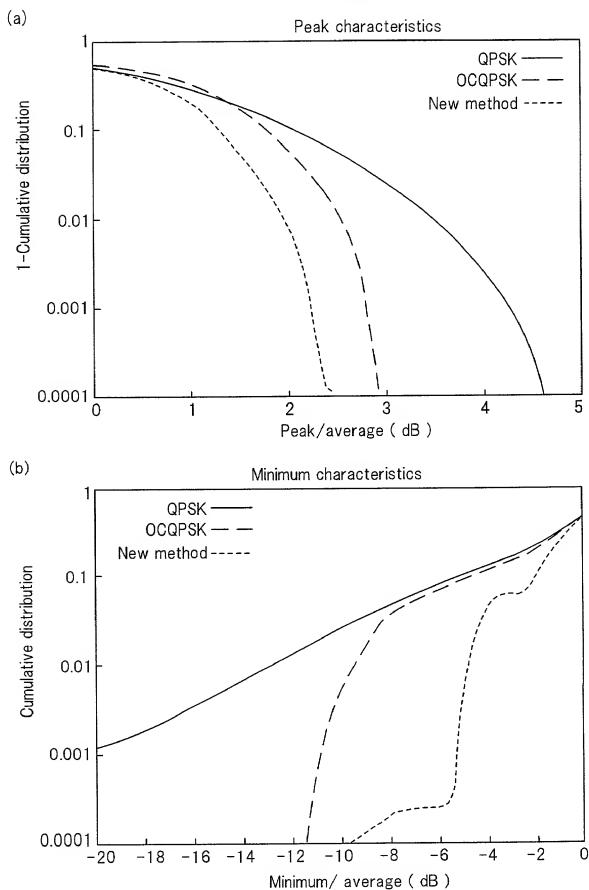
*FIG. 6*

# FIG. 7
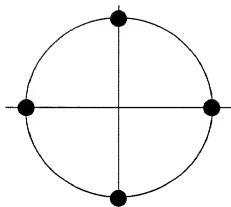


Signal points in the
first embodiment
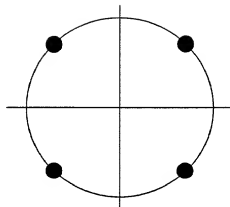
Signal points in the
second embodiment

*FIG. 8*



601 Mapping circuit

$D^{(0)}$

602

$C_0$

603

$D^{(2)}$

605

$C_1$

604

$D_i$

To the circuit in
Fig. 3(a) or Fig. 6

$D_q$

$D^{(1)}$

606

$C_0$

607

$D^{(3)}$

609

$C_1$

608
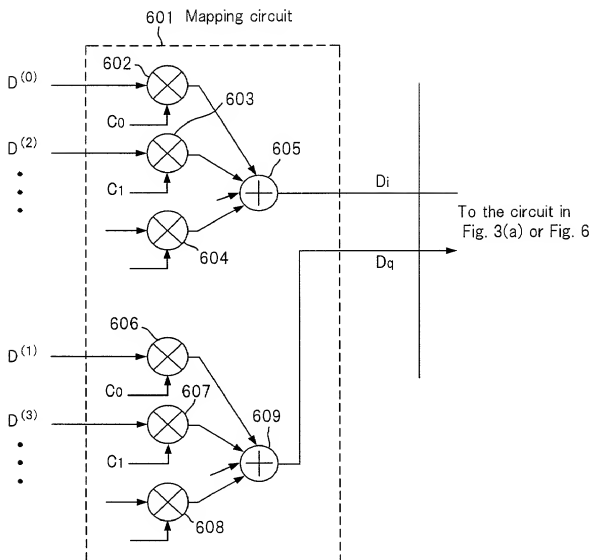
## RULE 63 (37 C.F.R. 1.63)
### DECLARATION AND POWER OF ATTORNEY
### FOR PATENT APPLICATION
### IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

As a below named inventor, I hereby declare that my residence, post office address and citizenship are as stated below next to my name, and I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

**SPREAD SPECTRUM COMMUNICATION SYSTEM**

the specification of which (**check** applicable **box(s)**):

☐ is attached hereto

☐ was filed on _____ as U.S. Application Serial No. _____ (Atty Dkt. No.)

☒ was filed as PCT international application No. **PCT/JP00/01162** on **February 29, 2000**

and (if applicable to U.S. or PCT application) was amended on **December 7, 2000**

I hereby state that I have reviewed and understand the contents of the above identified specification, including the claims, as amended by any amendment referred to above. I acknowledge the duty to disclose information which is material to the patentability of this application in accordance with 37 C.F.R. 1.56. I hereby claim foreign priority benefits under 35 U.S.C. 119/365 of any foreign application(s) for patent or inventor's certificate listed below and have also identified below any foreign application for patent or inventor's certificate having a filing date before that of the application on which priority is claimed or, if no priority is claimed, before the filing date of this application:

Priority Foreign Application(s): Patent Application

| **Application Number** | **Country** | **Day/Month/Year Filed** |
|---|---|---|
| Hei 11-53346 | Japan | 1/March/1999 |

I hereby claim the benefit under 35 U.S.C. §119(e) of any United States provisional application(s) listed below.

| **Application Number** | **Date/Month/Year Filed** |
|---|---|
| | |

I hereby claim the benefit under 35 U.S.C. 120/365 of all prior United States and PCT international applications listed above or below and, insofar as the subject matter of each of the claims of this application is not disclosed in such prior applications in the manner provided by the first paragraph of 35 U.S.C. 112, I acknowledge the duty to disclose material information as defined in 37 C.F.R. 1.56 which occurred between the filing date of the prior applications and the national or PCT international filing date of this application:

**Prior U.S./PCT Application(s):**

| **Application Serial No.** | **Day/Month/Year Filed** | **Status: patented pending, abandoned** |
|---|---|---|
| | | |

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon. And on behalf of the owner(s) hereof, I hereby appoint **NIXON & VANDERHYE P.C., 1100 North Glebe Rd., 8th Floor, Arlington, VA 22201-4714, telephone number (703) 816-4000 (to whom all communications are to be directed)**, and the following attorneys thereof (of the same address) individually and collectively owners'/owners' attorneys to prosecute this application and to transact all business in the Patent and Trademark Office connected therewith and with the resulting patent: I also authorize Nixon & Vanderhye to delete any attorney names/numbers no longer with the firm and to act and rely solely on instructions directly communicated from the person, assignee, attorney, firm, or other organization sending instructions to Nixon & Vanderhye on behalf of the owner(s).

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    (Zip Code) _____

**FOR ADDITIONAL INVENTORS, check box ☐ and attach sheet with same information and signature and date for each.**